Conclusion

Chapter 8

OEMC's Phase II will incorporate the 'Lessons Learned' documented in this report into the design of a 'showcase' treatment wetland.

Results of the site visits and data review were presented to the Task Force Members by the project team.

Lessons Learned

During the inventory of Colorado constructed treatment wetlands, the project team recorded practices and features that proved to be effective. The team also recorded 'lessons learned' from the first generation of Colorado treatment wetlands. It is the goal of this report to disseminate this collected data for the purpose of recording the current status of treatment wetlands and providing some guidance for future developments.

In order to refine design and management strategies, wetland professionals must have the ability to build on what has already been accomplished. Colorado has many treatment wetlands that are operating as intended, and in some cases, they are operating above expectations.

Design Methods

The primary objective of a treatment wetland is to remove key pollutants before discharging the system effluent. Often, BOD is considered the limiting pollutant and the wetland is designed to meet associated permit limitations.

Rule-of-thumb size ratios should only provide guidance for wetland design. Each wetland site should incorporate a comprehensive engineering study to determine wastewater characteristics, growth requirements, and climatological factors. Reaction kinetics of the top pollutants (typically BOD and TSS) of concern should be studied for maximum and minimum flow conditions.

Pretreatment

Constructed wetlands are one component of a treatment facility. It is imperative that all the system components are designed and operated to provide adequate treatment. Pretreatment of wastewater is especially important for successful wetland functioning. Influent requirements for the wetland must be considered when selecting pretreatment components.

Hydraulics

Treatment wetlands should be designed to implement simple hydraulic systems. These systems should minimize mechanical and electrical components wherever possible. The designer should address maintenance issues during the layout of the piping systems. Components of a successful hydraulic system are discussed below.

- **Gravity flow** – the wetland system should be designed with adequate slope and head to allow gravity flow through the entire system.
- **Simple hydraulics** – the plumbing should consist of pipes no smaller than 2", with a minimum of appurtences in order to prevent plugging.
- **System redundancy** – piping should be provided to allow wetland cells to be bypassed and dried out.
- **Adjustable water depth –** operators should be able to easily vary water level.
- **Cell drains –** the wetland cells should have the ability to be completely drained.
- **Designed for maintenance –**an easy method of cleaning pipes should be incorporated into the wetland design. Easily accessible pipe clean-out features, and 45° angles facilitate the use of hydrojets and other pipe cleansing mechanisms.
- **Hardy Materials –** in the selection of materials used in the wetland cells, consideration should be given to long-term operation and maintenance needs. Wood is susceptible to water wear, and destruction by muskrat and other wildlife. In addition, wood requires extra care during seasonal burning of the wetland cells. PVC pipe stub-outs may also create problems during burning of the wetland cells. Materials should be selected during the design of the wetland to withstand saturated conditions, as well as to fit into the long-term maintenance plans (i.e. harvesting and/or burning of wetland vegetation).

Site Selection

Constructed wetlands are land intensive treatment options. When selecting a site for implementation of a wetland system, the following factors should be considered.

- **Soils** – several sites in Colorado experienced significant settling (up to 18") of the entire wetland system, resulting in failure of the system hydraulic systems. This was the result of constructing the wetland on top of soils that could not support the weight of the wetlands.
- **Land Value** – consideration should be given to the 'best use' of intended land at build-out conditions.

Biological Perspective

Treatment wetland design requires input from biologists and botanists in order to develop high quality sites. It was noted that wetlands that scored high based on a biological perspective also consistently met discharge requirements. Conversely, wetlands that scored low from a biological perspective tended to have problems with wastewater treatment. The wetland should be designed to provide a high quality habitat that will thrive in its ecological siting.

- **Plant selection** - use of native plants is desirable, exotics should not be used.

- **Habitat design** - incorporate features that provide habitat for desired species, while minimizing nuisance species. Providing protection of berms and exclosures around pipe outlets will prevent muskrat destruction and discourage infestation. Designing a wetland to encourage a balance of species will minimize the potential for one species to dominate and thus become a nuisance.
- **Sizing for habitat value** - over-sizing wetland to encourage plant diversity
- **Irregular boundaries and shapes**– wetlands that have niches, islands, and other natural features will provide a higher quality wetland. Incorporate shapes, other than rectangles, that conform to available land and provide borders to improve habitat value.

Operation and Maintenance

Colorado's treatment wetlands scatter across the State. Some pockets of wetlands have been established as a result of 'word-of-mouth' discussions among towns operating treatment wetlands and those seeking treatment solutions. The project team found that there was a loose knit network of wetland operators state-wide. During the course of this project, a contact list was assembled to aid in the development of a network among every wastewater treatment operator currently using wetlands in Colorado.

- **Network** – operators of wetland facilities should develop a network in order to build on the experiences and knowledge in this field.
- **Sampling locations** - sampling ports should be provided to monitor water quality throughout the wetland. This gives the operator the ability to isolate treatment in the wetland from other treatment components
- **Design** – the long-term operation and maintenance scheme for the wetland should be determined during the initial design of the system.
- **Start-up period** – an operation plan should include a strategy for allowing the plants to mature. This may require operating the system at lower or higher water levels. In addition, consideration should be given to the planting schedule in order to allow slower growing plants to become established before introduction of more dominant species.

Energy

Constructed treatment wetlands can be designed to operate with minimal energy inputs. In order to take full advantage of this low energy treatment method, all components used at the wastewater treatment facility should be low energy consuming. Communities seeking low energy treatment methods should consider pairing a wetland system with other low energy using treatment components.

- **Gravity flow –** the treatment facility should be located at the lowest point in the community. Where available, sufficient elevation differences should be provided across the treatment facility to allow complete gravity flow.
- **Low Energy Primary Treatment –** selection of low energy treatment components should be considered.

- **Alternative Energy Sources –** energy requirements at a treatment facility could be completely satisfied by wind, solar, or other alternative energy sources.
- **Operation schedules –** energy consumption can be minimized by operating mechanical systems, such as lagoon aerators, on efficient schedules.

Human Use

Constructed treatment wetlands have great potential for providing ancillary benefits at minimal additional costs. Some of these potential benefits are discussed below.

- **Educational programs –** wetlands can be used as 'outdoor laboratories' to teach schoolchildren and adults about natural treatment processes.
- **Recreational activities -** trails, possibly connected to existing trails, can be incorporated to maximize public exposure to the wetlands. Other outdoor activities, such as bird and wildlife viewing can be enjoyed at the wetland site.
- **Public exposure** - interpretive centers can be provided to facilitate tours of the treatment wetland.

Added-Value Features

In addition to providing wastewater treatment, constructed treatment wetlands can also be designed as inviting areas for human and wildlife interaction. The following are components that should be included in a treatment wetland designed to encourage public visitation.

- Shape that blends into the natural setting
- Educational value, use of interpretive centers, educational displays
- Trails around wetland, with stops at interpretive centers
- Safety issues – need to protect public from raw waste, deep water
- Located off of major road, or in other heavily traveled area
- Handicap accessible
- Signage to facilitate self-touring
- Operator with interests in conducting tours, or local volunteer with interest and experience sufficient to conduct tours for educational purposes
- Use of alternative energy sources on site
- System design that provides nutrient removal (alternating open and vegetated water zones).

Conclusion

The project team visited constructed treatment wetlands that were functional in all regions of Colorado. Historical effluent monitoring reports indicate that the majority of these wetland systems have been able to consistently treat wastewater within permit limitations. Ancillary benefits, such as scenic views, and habitat viewing areas, were often provided as an unplanned component of the system.